

December 29, 2011

To: J. N. McKamy, Manager, US DOE NCSP

From: C. M. Hopper, Chair, US DOE NCSP CSSG *cmh*

Subject: **CSSG Tasking 2011-05, Report 2**

The CSSG has completed its action on Tasking 2011-05, *Independent Review of Godiva Safety*. As specified in the tasking, the review documentation is presented as two separate, stand-alone reports. This Report # 2 transmittal provides assessment of (a) select (Godiva-specific) DNFSB concerns stated in a letter dated August 5, 2010, and (b) issues related to implementation of Change Notice 3 of DOE-STD-3009-94 to Godiva operations.

The report was reviewed by the entire CSSG and comments were incorporated into the version that is attached. The attached version has the concurrence of the entire CSSG.

Cc: CSSG Members

A. N. Ellis

J. R. Felty

L. Scott

G.O. Udentia

## **Response to CSSG Tasking 2011-05, Report #2 of 2**

### **Independent Review of Godiva Safety: Assessment of Select DNFSB Issues, Implementation of DOE-STD-3009-94 CN-3**

#### **Introduction**

The Criticality Safety Support Group (CSSG) was directed in Tasking 2011-05 to provide a review of Godiva nuclear safety. As noted in the tasking statement (provided as Attachment 1), the response is provided as two separate, stand-alone reports. This report provides the assessment of select DNFSB issues and implementation of DOE-STD-3009-94 CN-3<sup>1</sup>.

A separate report (Report 1) addresses Godiva operational safety. In Report 1, the review team concluded that planned Godiva operations incorporate adequate operational safety and satisfy the applicable national consensus standards for critical experiment and fast pulse reactor safety [ANSI/ANS-1-2000 (R2007)<sup>2</sup>, ANSI/ANS-14.1-2004 (R2009)<sup>3</sup>].

#### **Executive Summary**

The issues addressed in this report are primarily non-safety concerns associated with regulatory compliance of the Documented Safety Analysis<sup>4</sup> (DSA) for Godiva operations. The team is concerned that efforts to resolve these documentation issues may lead to Godiva equipment or operational changes that present little safety benefit.

The review team concurs with the NNSA response<sup>5</sup> to DNFSB concerns<sup>6</sup> titled "Unmitigated Dose Analysis for Godiva," "Effects of Fuel Cracking," and "Design of Safety Instrumented Systems." (See Attachment 2 for citations of concerns and responses.) The responses commit that documentation will be revised.

The review team examined the NNSA response to the DNFSB concern titled "Improper Characterization of Safety-Related Controls." In addition, the team was presented with other concepts proposed by the National Critical Experiments Research Center (NCERC) staff to address the concern. (In the tasking statement, these other concepts are referred to as the "LANL technical analysis/basis for compliance with 3009 CN3").

To implement DOE-STD-3009-94 CN-3<sup>1</sup> and resolve the latter DNFSB concern, the review team recommends an alternate strategy. Within the Godiva safety basis documentation, the primary credited safety factors for protection of workers and collocated workers should be a combination of Material At Risk (MAR) inventory limits, facility shielding/confinement features, and (if practical) actinide sample containment. Several of the current Specific Administrative Controls (SACs) for excess reactivity limits could be eliminated.

This report recommends a specific path-forward for Godiva operational startup that allows for resolution of DOE-STD-3009-94 CN-3 documentation issues.

## **Review Team Composition**

Three CSSG members and eight ad hoc members were assigned to conduct the review and prepare this response for subsequent review and concurrence by the entire CSSG. The review team consisted of the following members:

### **[CSSG Members]**

Davis A. Reed (ORNL, writing team lead)  
James A. Morman (ANL)  
David P. Heinrichs (LLNL)

### **[Ad hoc Team Members]**

John T. Ford (SNL)  
Richard L. Coats (SNL)  
James R. Felty (SAIC)  
Bradley J. Embrey (NNSA CDNS)  
Richard C. Crowe (NNSA CDNS)  
Howard G. Goldin (NNSA NSO)  
Jerry E. Hicks (NNSA)  
Jeffrey L. Roberson (NNSA)

The review team included individuals with experience and expertise in a wide range of DOE nuclear reactor and nuclear facility operations, or activities that support nuclear operations, including:

- work at pulse reactor, critical experiment, and test/production reactor facilities,
- work at highly enriched uranium and plutonium production facilities,
- work at nuclear research laboratories,
- generation, maintenance, or implementation of safety basis documentation, and
- performance of operational or regulatory oversight.

## **Topics of the Review**

As directed by the tasking statement, the review team examined four specific DNFSB concerns related to Godiva operation<sup>6</sup>. The team also reviewed NNSA responses and proposed resolutions to those concerns<sup>5</sup>. From Reference 5, extracts citing the particular concerns and responses are provided as Attachment 2 to this report. The concerns are

- "Unmitigated Dose Analysis for Godiva,"
- "Effects of Fuel Cracking,"
- "Design of Safety Instrumented Systems," and
- "Improper Characterization of Safety-Related Controls."

The team was also tasked to review other concepts proposed by NCERC staff to address the last concern. This concern is directly related to a provision issued in March 2006 as part of DOE-STD-3009-94 CN-3.

## **Conduct of the Review**

Three teleconferences (October 21, November 17, and November 22, 2011) were held. The initial teleconference involving the DOE NCSP Manager and support staff, the CSSG Chair and several CSSG members, and select LANL/NCERC staff/management focused on review team selection, scope, and schedule. Following the first teleconference, the CSSG tasking statement was finalized and approved (October 25). Subsequently, the second and third teleconferences primarily involved the review team (identified in the approved tasking), key LANL staff supporting performance of the review, and DOE NCSP management.

The team performed an on-site visit to the DAF/NCERC on November 30, followed by two days of meetings at the Nevada Site Office (NSO).

The November 30 on-site visit provided the team with overviews of the Godiva machine, support equipment in/near the experimental room, and the control room facility. The visit provided opportunities for the review team to interact with LANL staff assigned for performance and management of Godiva operations, and to observe a complete "dry run" execution of the procedure for a Godiva pulse operation.

The December 1 meetings at the NSO involved extensive review and discussion of the review topics with LANL/NCERC staff and NSTec (National Security Technologies, LLC) safety basis management. The December 2 meetings involved assimilation of learned information and viewpoints of the review team members, with formulation of consensus opinions regarding review conclusions.

## **Review Observations by Topic Area**

### **A. Unmitigated Dose Analysis for Godiva**

This DNFSB concern is that for Godiva pulse operations, the DSA assumes a bounding reactivity insertion of \$1.20. The NNSA response addresses evaluation of a \$1.40 reactivity insertion as a beyond design basis event, and notes that DSA conclusions for the public are unchanged. DSA analysis shows that, based on the relative locations of the public and the DAF, complete vaporization of the Pu MAR inventory limit will result in a maximum dose to an off-site individual of ~1 rem. (The MAR limit includes the enriched uranium of the Godiva assembly, fission products, and sample materials. Sample materials are limited to 250 g <sup>239</sup>Pu or the equivalent radiological source term of other actinide elements/isotopes. The Pu MAR dominates potential dose consequences external to the facility.) The calculated maximum off-site dose of ~1 rem takes no credit for thermal deposition/plating effects or the safety-significant DAF confinement systems.

The NNSA<sup>5</sup> response to this DNFSB concern does not address dose consequences to collocated workers (defined as workers external to the DAF at a 100 meter distance). In the current DSA, qualitative consideration of collocated worker dose supports the

adoption of SAC limits for excess reactivity. A conservative quantitative transport analysis may predict a moderate (i.e., potentially greater than 5 rem) dose to collocated workers. If thermal deposition/plating effects and function of the safety-significant DAF confinement systems are credited in such an analysis, the potential dose to collocated workers may not be significant.

For workers within the facility, exclusion of personnel from the experiment room coupled with shielding and confinement provides adequate worker safety, even if full vaporization of the Pu MAR (250 g  $^{239}\text{Pu}$ -equivalent) is assumed.

Pulse-reactor specialists on the review team note that with increasing reactivity insertions, the probability for pre-initiation of the pulse increases. Pre-initiation limits further reactivity insertion, and thus limits the fission yield. For Godiva experiments without sample materials, the probability of obtaining pulses with insertions of \$1.40 or greater (before pulse initiation) is extremely small. For experiments involving actinide sample materials with a significant intrinsic neutron source (e.g., Pu with some  $^{240}\text{Pu}$  content), the amount of excess reactivity that may be inserted without realistic probability of pre-initiation is less than \$1.40. The review team concluded that Godiva machine properties and other available controls (shielding and confinement) result in no benefit from DSA limits for excess reactivity.

Revision of the DSA to treat a bounding Godiva accident, with assumed presence and vaporization of a 250 g  $^{239}\text{Pu}$ -equivalent sample, appears to be an acceptable response action for the DNFSB concern.

#### B. Effects of Fuel Cracking

The DNFSB concern is that the DSA omits a basis as to why fuel cracking is not a concern.

The NNSA response discusses how progression of fuel cracking, if of potential concern, will be detected through reproducibility measurements performed prior to each pulse operation. The potential for cracking to interfere with control (in particular, shutdown) mechanisms is discussed. The response observes that Godiva complies with a particular requirement of ANSI/ANS-14.1-2004, in that two independent safety devices for shutdown are incorporated into the machine design.

Based on the experience and expertise of pulse reactor specialists of the review team, fuel cracking may ultimately interfere with continued use of Godiva, but the potential for cracking to preclude termination of a Godiva pulse (or steady state) operation is not a valid safety concern. Considering the location of current cracks and the most likely locations for future cracks, crack propagation during a pulse cannot plausibly interfere with all available shutdown devices. If some portion of fuel were detached so as to potentially interfere with a subsequent pulse operation, such would readily be determined during preparations for that subsequent pulse (e.g., impaired function of the rod or safety block drives could be indicated by inability to seat the rods or block; if delayed critical

conditions could be still be obtained, the change in fuel configuration should be revealed by reproducibility measurements.)

The NNSA response commits to revision of DSA documentation; the review team concurs with this plan of action.

## C. Design of Safety Instrumented Systems

### C.1 Applicable Instrumentation Standards

The concern states that ANSI/ISA-84.01-1996, *Application of Instrumented Systems for the Process Industries*, was applied for the Critical Experiments Facility (now known as NCERC) design activities, but the most recent edition of that standard (ANSI/ISA-84.00.01-2004) should have been used. The NNSA response commits to researching project commitments regarding applicable standards, verifying what standards were used, and (if the appropriate set of standards was not used), evaluating the adequacy of the design process that was used. This NNSA response appears appropriate.

### C.2 Independence of Shutdown Controls

The NNSA response states that this issue centers on a specific failure scenario, where an operator is left in the experiment room during transition to remote operation mode for Godiva. The two available controls are for the operator to use a local SCRAM button, or for the operator to exit the room tripping the door interlock. Either action results in Godiva shutdown. Apparently, the engineering calculation referenced in the NNSA response did not correctly determine the combined probability that an operator might fail to use the SCRAM button and that the operator would also remain in the experiment room.

To mitigate this concern, other controls and indicators are available. These include a formal sweep of the experiment room to assure absence of personnel prior to establishment of remote operations, visual and audible signals within the experiment room to warn that remote operations are about to commence, and visible and audible indicators to control room operators (from video cameras and a microphone present in the experiment room.)

The scenario for an operator remaining present in the experiment room during remote (critical) operations of Godiva is very unlikely. A revised SIL calculation should support this team observation; the NNSA response appears appropriate.

### C.3 Operator Response Time to Activate Manual SCRAM

The DNFSB concern notes that in the DSA, "several accident scenarios require an operator to interpret the audible count rate ... and press the manual SCRAM button..."

The DNFSB concern concludes that "There are several problems with the design approach."

It is not clear that an improved design approach is a practical option to resolve this concern. Perhaps the DSA could simply assert some larger probability that operators will be present in the experiment room during approach to or onset of critical conditions, and that the operator response (to employ the SCRAM button) will be too slow. It is appropriate design practice to make manual SCRAM buttons available in the experiment room and in the control room, regardless of the fact that human response may not always be sufficiently rapid to limit the nuclear kinetics of a critical assembly.

The review team finds the majority of the NNSA response regarding operator response time to be acceptable. However, the NNSA response includes "... use of this credited control will be reexamined as part of the established action plan to address an ORR finding, to develop a control with the necessary timing to achieve the expected level of mitigation, or to remove the control with the presentation of an alternate strategy for attaining the desired risk mitigation..."

The NNSA response is conditionally acceptable, provided that the ORR corrective actions do not result in undue performance expectations or distractions for the operators.

#### D. Improper Characterization of Safety-Related Controls

The following discussion is specific to Godiva, although the noted DNFSB concern potentially applies to all NCERC critical assembly machines.

In order to implement Specific Administrative Controls (SACs) or Limiting Conditions of Operation (LCOs) related to reactivity limits for Godiva, operators utilize information provided by the Godiva Human Machine Interface (HMI). The HMI is controlled by a dedicated PLC (Programmable Logic Controller) that is completely separate from the safety system (startup and SCRAM channels) PLCs. This design approach is consistent with ANSI/ANS-1-2000, which requires that:

*The safety devices shall be able to perform their safety function independent of the assembly control system.*

The safety systems are designated, in the DSA, as "safety significant" whereas the HMI is classified as non-safety significant, or general service (GS), equipment. The designations of "non-safety significant" or "general service" do not imply that the resulting design or system components are inferior or of unaccepted reliability. Such equipment should be designed in accordance with accepted engineering practices and standards. However, it is often difficult and costly to apply (back fit) safety-significant status to equipment designed as general service.

During the NCERC design process, the HMI was designed to meet applicable engineering standards without expectation that the HMI would be classified (in the DSA)

as being "safety significant." However, during the design process, DOE-STD-3009-94 CN-2 was replaced by DOE-STD-3009-94 CN-3. The Change Notice 3 version of the standard added the following provision for systems, structures, and components (SSCs), in relation to DSA-specified Specific Administrative Controls (SACs):

*Identify SSCs whose failure would result in losing the ability to complete the action required by the SAC. These SSCs would also be considered safety-class or safety-significant based on the significance of the SAC safety function.*

The NCERC design process and DSA development continued to completion without determination of whether the HMI (or other components used to meet the SACs and LCOs) warranted "safety significant" designation. The DSA submitted for NSO approval stated it was generated in accordance with DOE-STD-3009-94 CN-3. The NSO Safety Evaluation Report (SER) presumed and approved the DSA on the basis that the document was DOE-STD-3009-94 CN-3 compliant.

Since issuance of the DNFSB Staff Issue Report, a PISA (Potentially Inadequate Safety Analysis) was declared for Godiva, related to use of non-safety significant SSCs to support performance of Godiva SACs related to excess reactivity limits. The NSO has approved Godiva operations with a compensatory measure that the MAR limit for Godiva will be restricted (samples containing <sup>239</sup>Pu or other actinides may not be used in Godiva experiments).

The NNSA response does provide rationale that for some excess-reactivity SACs, failure of the HMI should not result in failure to meet the SACs (thus, the HMI does not warrant safety-significant designation for those particular SACs). However, the NNSA response does not address the SAC for excess reactivity limits for Godiva pulses, or other SACs and LCOs that do not involve excess reactivity limits (e.g., SACs that focus on worker safety).

It does not appear that a comprehensive extent-of-condition review of the DSA has been performed to examine all SACs and LCOs, to determine if failure of the SSCs used could result in failure to meet the SACs or LCOs.

The NNSA response to this DNFSB concern appears to be incomplete.

E. LANL Technical Analysis/Basis for Complying with DOE-STD-3009-94 CN-3 (CN-3)

The review team was presented with other concepts proposed by NCERC staff to address the DNFSB concern regarding characterization of safety related controls.

One concept discussed was of the type noted in the NNSA response. For some SACs, there may be valid technical arguments that failure of the non-safety significant SSCs used to meet the SAC (or LCO) will not preclude compliance to the SAC/LCO. This approach may not be applicable to all SACs/LCOs. Where this approach is valid and is

to be applied, the basis for compliance to the noted CN-3 provision needs to be formally documented.

Compliance with SACs for excess reactivity limits requires proper operator action, and the failure probability of the HMI equipment is already much lower than for human error probability. Therefore, retrofitting of HMI components to meet "safety significant" status is of little benefit for some SACs and DSA accident scenarios. This rationale might support an exemption from the noted CN-3 provision, for certain SACs or LCOs.

The least desirable and least practical approach is to redesign portions of the HMI to essentially become part of the "safety systems" for Godiva operations. As noted in Report 1 for CSSG Tasking 2011-05, proposed Godiva operations are deemed to be safe and in compliance with applicable national standards. Application of resources to modify the HMI or other non-safety-significant equipment, solely to conform to CN-3, will result in negligible safety benefit.

Report 1 for CSSG Tasking 2011-05 recommends that NSTec and NCERC staff should work with NSO staff to expedite the DSA revision to address Godiva assembly operations. This effort will require addressing CN-3 issues specific to local Godiva operations (e.g., control rod maintenance, Godiva assembly or disassembly), since the non-safety significant lockout switches are used to restrict operation of control rod drives while personnel are present in the experiment room.

### **Team Perspectives Regarding What is Important for Safety, and What Should (Or Should Not) Be Credited in the DSA for Safety**

#### Public Safety

The primary concern for public safety is a severe Godiva accident resulting in inhalation potential for experimental materials that have radiotoxicity significantly greater than that of highly enriched uranium.

The primary factors for safety of the public are the location of the DAF and limitation of MAR inventory.

For Godiva operations, DSA specification of a MAR inventory limit is all that is warranted for public safety.

#### Worker Safety

The primary concern for worker safety is exposure of personnel to direct (unshielded) radiation from a critical assembly.

The primary factors for worker safety during remote operations are the shielding and confinement provided by facility design. Controls to assure personnel are absent from the experiment room during remote operations are important to worker safety. Controls

used during local operations to preclude a critical configuration are likewise important to worker safety.

Regardless of what equipment may assist in avoiding personnel exposure to a critical configuration, the level of protection obtained will be primarily reliant on operator action.

#### Collocated Worker Safety

The primary concern for collocated workers is similar to that for the public: a severe Godiva accident resulting in dispersion and inhalation of radiotoxic materials.

The primary factors for collocated worker safety are the shielding and confinement provided by facility design and the limitation of MAR inventory.

#### Utility of Godiva Reactivity Limits for Safety

The DSA identifies two administratively implemented reactivity limits for Godiva, paraphrased as follows:

- (LCO) The Godiva assembly will be configured such that the maximum excess reactivity available is \$1.40, including reactivity contributions that may be provided by sample materials.
- (SAC) For burst operations, the limit for excess inserted reactivity is \$1.15.

These limits do not provide any meaningful worker or public safety. The current DSA basis for the LCO and SAC is qualitative assessment of collocated worker safety.

Assuming complete vaporization of the Pu MAR limit, a conservative transport analysis (quantitative) may predict a moderate dose to collocated workers. If thermal deposition/plating effects and function of the safety-significant DAF confinement systems are credited, the potential dose to collocated workers may not be significant.

If the 250 g Pu MAR is assumed to be Pu with ~3%  $^{240}\text{Pu}$ , the sample neutron source strength is two orders of magnitude greater than that of the Godiva assembly. This greatly reduces the likelihood of achieving large reactivity insertions and would preclude complete vaporization of a Pu sample (of this mass). The potential for achieving a Pu MAR release comparable to that of the beyond design basis DSA scenario is considered to be extremely low, irrespective of DSA limits for excess reactivity.

The review team judges that DSA specification of Godiva excess reactivity limits provide only minimal incremental protection to collocated workers beyond that already afforded by shielding and confinement. If improved collocated worker safety is perceived as necessary, engineered features for containment of sample materials (Pu or other actinides) should be investigated.

## Recommendations for a Path-Forward

The review team recommends the following near-term and future actions to achieve Godiva startup and to ultimately resolve DOE-STD-3009-94 CN-3 issues:

### Near Term Actions

Achieve Godiva assembly by

- Performing an extent-of-condition review for all Godiva-related SACs and LCOs regarding application of DOE-STD-3009-94 CN-3.
- Evaluating controls required by the NCS evaluation for the Godiva assembly operation and performing DSA changes (consistent with DOE-STD-3009-94 CN-3) as appropriate to address assembly (and disassembly) activities.
- Performing assembly of Godiva according to the NCS evaluation and revised DSA.
- Performing startup and near-term operations of Godiva under the current PISA (with MAR restriction for collocated worker safety).

### Future Actions

If Pu samples (or other samples of significantly greater radiotoxicity than highly enriched uranium) are required in Godiva experiments, then perform either of the following:

- Apply design features for containment of the sample materials; modify the DSA to credit use of containment.
- Perform a review of the existing process hazards analysis (PrHA); determine a revised DSA control set based on <sup>239</sup>Pu-equivalent MAR and confinement.

For either option, an outcome of the DSA revision should be elimination of DSA controls related to reactivity limits.

## Conclusions

The conclusion of Report 1 of CSSG Tasking 2011-05 is restated:

*Planned Godiva operations incorporate adequate operational safety, consistent with guidance of national consensus standards ANSI/ANS-1-2000 and ANSI/ANS-14.1-2004.*

The conclusions of this report are as follows:

- The review team concurs with the NNSA response to DNFSB concerns titled "Unmitigated Dose Analysis for Godiva," "Effects of Fuel Cracking," and "Design of Safety Instrumented Systems."
- The team provides recommendations for a path-forward for near-term actions (Godiva assembly and startup) and future actions (experiments with samples of <sup>239</sup>Pu or other actinides) that allows for resolution of DOE-STD-3009-94 CN-3 documentation issues.

## References

1. DOE-STD-3009-94, Change Notice 3, March 2006, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*.
2. ANSI/ANS-1-2000 (R2007), *Conduct of Critical Experiments*.
3. ANSI/ANS-14.1-2004 (R2009), *Operation of Fast Pulse Reactors*.
4. LLNL-MI-407120, *Device Assembly Facility Documented Safety Analysis Addendum for Criticality Experiments Facility Operations (DSA)*, April 2009.
5. Memo, Donald L. Cook (NNSA) to Peter S. Winokur (DNFSB) dated February 10, 2011, with attachment titled "Response to Defense Nuclear Facilities Safety Board Issues Concerning Deficiencies in the Accident Analysis, Control Set, and Safety Design at the Criticality Experiments Facility."
6. Memo, Peter S. Winokur (DNFSB) to Thomas O. D'Agostino (NNSA) dated August 5, 2010, with enclosure titled "Defense Nuclear Facilities Safety Board Staff Issue Report, June 22, 2010."
7. ANSI/ISA-84.01-1996, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*.
8. ANSI/ISA-84.00.01-2004 Part 1, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements*.
9. NCS-CSED-11-002, *Criticality Safety Evaluation for Godiva-IV Assembly and Disassembly Operations at the DAF*, May 6, 2010.

**Attachment 1**

**CSSG Tasking 2011-05**

**CSSG Tasking 2011-05**

Date Issued: 25 October 2011

Task Title: *Independent Review of Godiva Safety*

**Task Statement:**

The CSSG is directed to oversee and participate in an Independent Review of Godiva Safety prior to its reassembly and start-up at the Nevada National Security Site Device Assembly Facility (DAF) National Criticality Experiments Research Center (NCERC) and issue a US DOE NCSP CSSG Tasking 2011-05 Response.

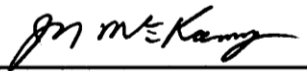
**Resources:**

The review will be conducted by a Review Team that is comprised of selected CSSG members who are supplemented by ad hoc members with expertise in fast pulse reactor safety and safety basis documentation. The Review Team is to draft and provide a final tasking Response to the CSSG Deputy Chair. The CSSG Deputy Chair will distribute the Response to the full CSSG membership for review and comment. The CSSG Deputy Chair will address the CSSG member comments and forward the resulting revised Response to the CSSG Chair for transmittal to the NCSP Manager. Contractor CSSG members will use their FY12 NCSP CSSG support funding as appropriate; DOE CSSG members will utilize support from their site offices. CSSG emeritus members may be included on the team on a voluntary basis. The NCSP Manager will assure that support is available for ad hoc members.

**Task Deliverables:**

1. CSSG Review Team receives advance materials by October 21, 2011, for examination prior to the site visit.
2. CSSG Review Team meets for the work period 30 November through 2 December. A DAF NCERC site visit will be conducted to observe the planned operating environment of Godiva and its control systems. The balance of the work period may be conducted at the Nevada Site Facility or the DAF NCERC as appropriate.
3. CSSG Review Team develops a draft "US DOE NCSP CSSG Tasking 2011-05 Response" by December 9, 2011 that addresses the CSSG Tasking 2011-05 General Review Topics/Guidance/Information (see CSSG Tasking 2011-05 Attachment).
4. CSSG provides comments on the draft Response by December 14, 2011.
5. CSSG Chair briefs the NCSP Manager on the Response by December 16, 2011.
6. CSSG Chair transmits the final Response to the NCSP Manager by December 29, 2011.

**Task due date: December 29, 2011**

Signed:  10/25/2011  
Jerry N. McKamy, Manager US DOE NCSP

## **CSSG Tasking 2011-05 Attachment**

### **CSSG Tasking 2011-05 General Review Topics/Guidance/Information**

#### **1. Godiva Operational Safety, i.e.,**

- a. Godiva System Design Description
- b. Human Machine Interface
- c. Safety Channels and their associated Safety Integrity Level analyses
- d. Nuclear Safety Control Set
- e. Operational Procedures
- f. Godiva Experimental Planning and Approval Process
- g. Godiva Start-up Plans/Schedule

#### **2. Stand-alone review responses regarding**

- a. The DNFSB issues relating Godiva as stated in their letter dated August 5, 2010 (see “DNFSB Letter on CEF Start-Up August 5, 2010 and its attached June 22, 2010 “Staff Issue Report”) regarding
  - i. *Inadequate Accident Analysis of*
    1. “Unmitigated Dose Analysis for Godiva”
    2. “Effects of Fuel Cracking”
  - ii. *Inadequate Control Set of*
    1. “Design of Safety Instrumented Systems”
  - iii. *Improper Characterization of Safety-Related Controls*
- b. The “LANL technical analysis/basis for compliance with 3009 CN3 for some SACs as an alternate accident analysis methodology at the DAF NCERC per established protocols for approving alternate methodology(ies) for implementing DOE-STD-3009 requirements of 10 CFR 830.”

### **CSSG Tasking 2011-05 Subgroup Review Team and ad hoc Members**

#### **Selected CSSG Review Team members include:**

- Davis A. Reed, ORNL (CSSG Lead and Coordinator)  
[reedda@ornl.gov](mailto:reedda@ornl.gov)  
865-576-6359
- David P. Heinrichs, LLNL  
[heinrichs1@llnl.gov](mailto:heinrichs1@llnl.gov)  
925-667-1710  
925-424-5679
- James A. Morman, ANL  
[Jamorman@anl.gov](mailto:Jamorman@anl.gov)  
630-252-6076  
630-531-0911

**Ad hoc Review Team members include:**

- John T. Ford (SNL)  
[jtford@sandia.gov](mailto:jtford@sandia.gov)  
Work: 505-845-3327
- Richard L. Coats (SNL)  
[rlcoats@sandia.gov](mailto:rlcoats@sandia.gov)  
Work: 505-845-3218
- James R. Felty (SAIC and Member of ANSI/ANS 14.1)  
[James.felty@nnsa.doe.gov](mailto:James.felty@nnsa.doe.gov)  
Mobile: 301-640-6805
- Bradley J. Embrey (NNSA CDNS)  
[Bradley.embrey@nnsa.doe.gov](mailto:Bradley.embrey@nnsa.doe.gov)  
Work: 202-586-9400
- Richard C. Crowe (NNSA DNS)  
[Richard.crowe@nnsa.doe.gov](mailto:Richard.crowe@nnsa.doe.gov)  
Work: 301-903-6214
- Howard G. Goldin (NNSA NSO)  
[goldinh@nv.doe.gov](mailto:goldinh@nv.doe.gov)  
Work: 702-295-1289
- Jerry E. Hicks  
[Jerry.hicks@nnsa.doe.gov](mailto:Jerry.hicks@nnsa.doe.gov)  
Work: 505-845-6287
- Jeffry L. Roberson  
[Jeffry.roberson@nnsa.doe.gov](mailto:Jeffry.roberson@nnsa.doe.gov)  
Work: 301-903-9228

**Point of Contact for DAF NCERC Site Access Arrangements**

- Robert Margevicius (LANL)  
[margevicius@lanl.gov](mailto:margevicius@lanl.gov)  
Work: 505-665-8965

**Point of Contact for Nevada Site Facility Meeting Room Space Arrangements**

- Dirk Schmidhofer  
[schmidhofer@nv.doe.gov](mailto:schmidhofer@nv.doe.gov)  
Work: 702-295-0159

**Distribution of Work Assignments/Responsibilities:**

Under the CSSG leadership and coordination of Davis A. Reed, David P. Heinrichs, James A. Morman and Davis A. Reed are to participate, contribute, monitor and produce the US DOE NCSP CSSG Tasking 2011-05 Response as assisted by the expertise of Review Team ad hoc members as follows:

1. John T. Ford, Richard L. Coats, and James R. Felty are to focus on reviewing and reporting on the adequacy of Godiva operational safety, e.g.,
  - a. Godiva System Design Description

- b. Human Machine Interface
  - c. Safety Channels and their associated Safety Integrity Level analyses
  - d. Nuclear Safety Control Set
  - e. Operational Procedures
  - f. Godiva Experimental Planning and Approval Process
  - g. Godiva Start-up Plans/Schedule
2. Bradley J. Embrey, Richard C. Crowe, Howard G. Goldin, Jerry E. Hicks and Jeffry L. Roberson are to focus on reviewing and reporting on
- a. DNFSB issues relating Godiva as stated in their letter dated August 5, 2010 (see embedded "DNFSB Letter on CEF Start-Up August 5, 2010 and its attached June 22, 2010 "Staff Issue Report") regarding
    - i. *Inadequate Accident Analysis* of
      - 1. "Unmitigated Dose Analysis for Godiva"
      - 2. "Effects of Fuel Cracking"
    - ii. *Inadequate Control Set* of
      - 1. "Design of Safety Instrumented Systems"
    - iii. *Improper Characterization of Safety-Related Controls*
  - b. The "LANL technical analysis/basis for compliance with 3009 CN3 for some SACs as an alternate accident analysis methodology at the DAF NCERC per established protocols for approving alternate methodology(ies) for implementing DOE-STD-3009 requirements of 10 CFR 830."
3. Robert W. Margevicius is to facilitate Review Team access to the DAF NCERC.
4. Dirk Schmidhofer can assist in arranging Review Team meeting and work area.
5. All members of the Review Team (i.e., selected CSSG and ad hoc members) and the full CSSG membership are to examine the Tasking Responses. A "Difference of Professional Opinion" section shall be provided in each of the focused responses to address Review Team or CSSG member lack of concurrence with the consensus Tasking Response.

## **Attachment 2**

### **Select DNSFB Concerns Related to Godiva, NNSA Responses**

The following tables of information were extracted from Reference 5. The extracted information is limited to specific DNFSB concerns listed in the tasking statement for CSSG Tasking 2011-05. The information has been reformatted and information not relevant to objectives of this review have been omitted (project completion dates for proposed corrective actions, organizations proposed to perform corrective actions).

<b>DNFSB Issue</b> <b>Unmitigated Dose Analysis for Godiva</b>	<b>Path Forward</b>
<p>The design basis event for the accident analysis of the Godiva critical assembly machine is a \$1.20 insertion of reactivity above delayed critical. This amount of reactivity based upon the specific administrative control limit of \$1.15 with an additional \$0.05 that accounts for core cooling. The unmitigated dose analysis is based upon this administrative control, which is inconsistent with the methodology recommended by the safe harbor of the Nuclear Safety Management rule, Title 10 Code of Federal Regulations, Part 830. This accident is not bounding, as failure of this administrative control could result in credible reactivity insertions up to or possibly exceeding \$1.40.</p>	<p>The Specific Administrative Control (SAC) that limits the maximum excess reactivity inserted for burst operations \$1.15 in order to prevent subsequent release of airborne radiological material at risk was perceived to be consistent with the safe harbor methodologies of the Nuclear Safety Management rule for establishing initial conditions for the accident analysis. A superprompt burst accident on Godiva involving \$1.20 reactivity insertion was deemed to be the bounding reactivity insertion accident. It was understood, by the knowledgeable team preparing the Documented Safety Analysis (DSA) that insertions above \$1.15 rapidly decrease in likelihood, ultimately becoming impossible for all practical intent as stray neutron pre-initiation of the sequence at reactivity insertion levels higher than \$1.15 becomes inevitable. In particular, the intrinsic neutron density of a plutonium sample in the glory hole, the primary release source of concern, would ensure such pre-initiation.</p> <p>The chosen bounding accident was determined to result in the melting of plutonium and was qualitatively assigned a consequence category "B" range for the public. This consequence for the design basis accident is conservative because the maximum possible consequence of entire Godiva plutonium sample vaporizing for the \$1.40 beyond design basis accident would also result in a consequence category "B" range for the public. The postulated dose to the public would be less than 1 rem for this beyond design basis accident and is less than the 25 rem Total Effective Dose Equivalent (TEDE) to the maximally exposed off-site individual (MOI) dictating the application of safety class controls. Moreover, the use of this worst case bounding consequence (i.e., vaporization of entire plutonium sample) ensures that the appropriate defense in depth controls are selected to effectively mitigate the risk of this bounding accident to acceptable levels. Therefore, the DSA preparation team believed the analysis was appropriately bounding and that the unmitigated consequences were conservative because of the use of consequences associated with the full vaporization of plutonium and the understood physical limitations of achieving maximum excess reactivity in excess of \$1.15.</p>

<b>DNFSB Issue</b> <b>Unmitigated Dose Analysis for Godiva</b> <b>(Continued)</b>	<b>Path Forward</b> <b>(Continued)</b>
	<p>A Beyond Design Basis (BDB) event was done for a postulated accident involving an excess reactivity insertion of \$1.40 on the Godiva critical assembly. Godiva is administratively controlled to have a maximum excess reactivity loading of \$1.40 and a maximum reactivity insertion of \$1.15 above delayed critical. As indicated in DOE-STD-3009, the Nuclear Safety Management Rule requires consideration of the need for analysis of accidents, which may be beyond the design basis of the facility to provide a perspective of the residual risk associated with the operation of the facility. As shown in supporting analyses, at a \$1.40 insertion all of a Godiva plutonium sample and a small fraction of the Godiva highly enriched uranium core could vaporize. The postulated dose to the public would be less than 1 rem and continue to correspond to a public risk consequence category designation of "B" with the entire plutonium sample vaporizing.</p> <p>As indicated above, the design basis and beyond design basis accidents selected for Godiva excess reactivity excursions represent the range of fuel consequences from melting to vaporizing. The public consequences used in control selection for this range of phenomena associated fuel condition remains the same as a public risk consequence category designation of "B." Thus, a design basis accident perceived to be more bounding would have no impact on the unmitigated bounding consequence used in the process hazards of analysis used to determine the preventive and mitigative controls to attain acceptable risk.</p> <p>However, to provide enhanced clarity the design basis accident will be revised to provide the bounding release (i.e., vaporization of entire Plutonium sample) that could occur regardless of reactivity insertion. This revision will eliminate the Godiva excess reactivity insertion limit of \$1.15 for burst operations as an initial condition. Instead, this limit will be applied as a control, as appropriate, in mitigating an excess reactivity accident to protect the Critical Assembly Machine (CAM) from this level of unplanned reactivity excursion. These changes will be pursued in accordance with the established action plan to address an Operational Readiness Review (ORR) finding, since this conservatism was already applied in the process hazards analysis evaluating this accident.</p>

<b>DNFSB Issue</b> <b>Effects of Fuel Cracking</b>	<b>Path Forward</b>
<p>The documented safety analysis ruled out fuel cracking as an operational concern on the Godiva critical assembly machine, despite the fact that fuel cracking previously occurred on Godiva during prompt-critical operations with temperature rises of 450°C. The statement that "Experiences at both LANL and Sandia National Laboratories have shown that, at least initially, these cracks do not pose operational difficulties" is not supported by any further technical justification in the accident analysis and is inappropriately eliminated from consideration for control or inspection.</p>	<p>The indicated quote is completed in Section 2.5.4.7, Thermal, and Nuclear Characteristics of Godiva in the DSA with the following sentences " ... In the initial stages, this cracking is difficult to identify, and the prompt-burst assemblies at both laboratories may be operating with some cracking in the fuel plates. Cracks were found to have decreased the overall reactivity of the assembly. Therefore, it is concluded that the cracks do not present an operational or safety issue." The complete citation in summary indicates that cracks have not caused operational difficulties and they have been found to decrease the overall reactivity of the assembly rather than present an increased reactivity concern. However, the reference to cracking raises other potential concerns if new information from the present operating experience is found (e.g., through operational events) that indicates cracking has become significantly further degraded with resulting effects that have not been experienced to date (e.g., Safety Shutdown Mechanism obstruction caused by cracking). Godiva design and operations are compliant to American National Standards Institute/American Nuclear Society (ANSI/ANS) ANSI/ANS-14.1 -2004, <i>Operation of Fast Pulse Reactors</i>. Requirements from this standard include provisions for at least two independent safety devices (such as safety block and control elements) that shall be capable of shutting down the reactor under the most reactive experimental arrangement to be modified and requirements for the reproducibility of experimental data.</p> <p>The safety function of the SCRAM Safety System (SSS) and Safety Shutdown Mechanism (SSM) to SCRAM the critical assembly (rapidly move the critical assembly to a subcritical level) when indicated to do so by the state of the sensors or by a loss of power, demonstrates that Section 5.2 of ANSI/ANS-14.1-2004 is met. The associated daily and annual surveillance tests for these independent systems involve movement of the safety block and control rods that provide associated confidence relative to unobstructed movement of the safety devices. The reproducibility requirement ensures that measured core conditions match expected core conditions as part of deliberate standard based critical operations. It is anticipated that reduced reactivity caused by fuel cracking would be identified by these activities.</p>

<b>DNFSB Issue Effects of Fuel Cracking (Continued)</b>	<b>Path Forward (Continued)</b>
	<p>Attachment A, Section A.1.5 of DOE G 424.1-1A, "Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements," indicates "certain accidents or malfunctions are not treated in the nuclear facility's existing safety analyses because their effects are bounded by similar events with the same control set that are analyzed." The surveillance testing of the SSS and SSM required by Technical Safety Requirement (TSR) Surveillance Requirement (SR) 4.8.2 upon startup of a CAM, that involves the physical movement of the safety block and control rods, provide assurance and associated controls to identify issues with obstructed movement, even though these controls were not derived for that specific purpose. If an operational event is discovered by this testing that identifies an issue with movement, a Potential Inadequacy in the Documented Safety Analysis (PISA) would be declared, compensatory measures defined to assure safety and an USQ determination initiated. As an enhancement to the DSA, the hazard identification and evaluation will be expanded to include fuel cracking concerns causing potential obstructions to safety block and control rod travel as part of planned changes to address ORR findings.</p>

<b>DNFSB Issue</b> <b>Design of Safety Instrumented Systems:</b> <b>Applicable Instrumentation Standards</b>	<b>Path Forward</b>
<p>The LANL <i>Engineering Standards Manual</i> (ISD 341-2) specifies the safety instrumented system design requirements for the CEF project. The manual amplifies the requirements provided in ANSI/ISA-84.01-1996, <i>Application of Safety Instrumented Systems for the Process Industries</i>, which is the selected national consensus standard for use in designing and operating safety instrumented systems at CEF. Of note, this standard underwent significant revision in 2004 and was reissued as ANSI/ISA-84.00.01-2004 to reflect technological advances and changes in consensus. The system design for CEF does not incorporate these changes. Additionally, there are several instances where the current design does not meet the requirements of any of these design standards.</p>	<p>The report observations and comments assert that there are "several instances" where the current design does not meet the requirements of the LANL <i>Engineering Standards Manual</i> (ISD 341-2) and ANSI/ISA-84.01-1996. The observations and comments also assert that ANSI/ISA-84.01 went through a substantial upgrade in 2004 and that the CEF design did not incorporate these changes. Our path forward for addressing this comment is as follows.</p> <ol style="list-style-type: none"> <li>1. Research the project commitments with regard to the applicable standards. At present, we know that ISD 341-2 and ANSI/ISA-84.01-2004 did not exist during the design phase of the project. Clearly, ANSI/ISA-84.01-1996 did exist during the design phase of the project.</li> <li>2. Re-affirm (or not) that the project followed the appropriate <u>set</u> of standards during the design phase.</li> <li>3. If it is concluded that the project did not follow the appropriate <u>set</u> of standards, then initiate discussions with Nevada Site Office with regard to evaluating the adequacy of the design process as it was used.</li> </ol>

<b>DNFSB Issue</b> <b>Design of Safety Instrumented Systems:</b> <b>Independence of Shutdown Controls</b>	<b>Path Forward</b>
<p>The CEF project employs safety significant instrumented systems to achieve the controls required by the documented safety analysis. Three independent protection layers, which form the machine SCRAM systems, have been assigned a required risk reduction factor and safety integrity level, which indicate the desired system reliability. These protection layers are assigned as safety instrumented functions that work in concert to ensure the controls specified in the DSA are achieved. The Board's staff noted that the protection layers all share the same final elements and as such are not independent. This is significant in that the Layer of Protection Analysis calculation credits these systems for their independence.</p>	<p>The report observations and comments assert that the three layers of protection that form the machine SCRAM systems all share the same final element and are therefore not independent. This assertion is significant because the Layer of Protection Analysis (LOPA) credits these systems for their independence. In a follow-on teleconference with the Board staff, it was stated that the issue may not be a common final element issue, but rather the issue may be with CEF-ENG-CAL-0465, LOPA Analysis for Safety Integrity Level (SIL) Determination of the SCRAM System; Hazard ID REA-20. Our path forward for addressing this comment is as follows.</p> <ol style="list-style-type: none"> <li>1. Analyze the CEF Layer of Protection Analysis and determine if the protection layers are independent or not.</li> <li>2. If there is an issue with respect to independence, revise the analysis to address this issue.</li> <li>3. Evaluate any modifications to the LOPA with respect to impact on the required SIL and CEF SIL calculation.</li> <li>4. Provide report to Nevada Site Office with results of LOPA actions and any impact to the CEF SIS design.</li> </ol>

<b>DNFSB Issue</b> <b>Design of Safety Instrumented Systems:</b> <b>Operator Response Time to Activate</b> <b>Manual SCRAM</b>	<b>Path Forward</b>
<p>One safety instrumented function credited in several accident scenarios requires an operator to interpret the audible count rate from safety significant startup and audible neutron counters and press the manual SCRAM button to shutdown the system if the count rate is abnormal. There are several problems with the design approach.</p>	<p>The manual SCRAM is credited as a dual action/control with the audible startup counters for three Godiva reactivity insertion accidents and one Flat-Top reactivity insertion accident. Two of the Godiva reactivity accident scenarios pertain to postulated accidents in local operations where safety block/control rods are inserted, while control rod/safety block checks are being performed. The other two postulated scenarios for Godiva and Flat-Top involve leaving a worker in the building during the transition from the pre-operational state to remote operations. In all of these scenarios, the manual SCRAM and audible startup counters are credited along with other controls for providing a one bin frequency reduction.</p> <p>While the audible neutron counter is part of a credited safety significant system, an appropriate control regarding the operator response is not well linked to the instrument indication. Further review of this concern indicates that a time-sensitive SAC was not written for the required operator response based on an understanding that operator training and expertise on ANS-I ensured appropriate operator response to abnormal audible startup counter readings. Established human reliability analysis methodologies allow for human response actions to prevent or mitigate an accident sequence. Taking into account the two-person rule, it is reasonable to expect one of the operators to initiate manual SCRAM. Unlike a handstacking scenario where the criticality may have already occurred, for the local operation based scenarios there may be adequate time to interrupt the accident progression with the operator initiated manual SCRAM. However, the use of this credited control will be reexamined as part of the established action plan to address an ORR finding, to develop a control with the necessary timing to achieve the level of expected mitigation, or to remove the control with the presentation of an alternate strategy for attaining the desired risk mitigation for these defined accident scenarios. TSR implementation procedures will be revised to reflect the time sensitivity for completing the required actions. This enhancement to the CEF DSA will be completed in accordance with the established action plan to address an ORR finding.</p>

<b>DNFSB Issue</b> <b>Design of Safety Instrumented Systems:</b> <b>Operator Response Time to Activate</b> <b>Manual SCRAM</b> <b>(Continued)</b>	<b>Path Forward</b> <b>(Continued)</b>
	<p>Note: The CEF DSA uses the human error probabilities in NUREG/CR-1278, adjusted for DAF experience, and judgment on the typical number of activities per operation per year for significant human actions. A reduction factor of 0.1 is assigned to these types of actions based on this standard. The practice of using NUREG/CR-1278 for the assignment of human error has been a common practice in both the commercial nuclear industry and the Department of Energy; however, the defensibility of this reduction factor will be reexamined recognizing the time sensitivity of completing the required actions.</p>

<b>DNFSB Issue</b> <b>Improper Characterization of Safety-Related Controls</b>	<b>Path Forward</b>
<p>Operators determine the point of delayed criticality and the system excess reactivity for critical assembly machines by performing calculations during the conduct of experiments. System excess reactivity is administratively controlled as a TSR. The operators use human machine interfaces to remotely conduct the experiments and these interfaces provide data, including control rod position and neutron population, for example, that directly supports execution of the related TSRs. While excess reactivity limits are credited to mitigate the severity of each postulated reactivity insertion accident, the human machine interface consoles are not designated as safety significant. This is inconsistent with the safety function performed by these systems, and requires evaluation to ensure that the credited excess reactivity limits can be implemented as designed.</p>	<p>The DNFSB trip report asserts that the human machine interface consoles should be safety significant as they are used to collect and display data that is used to execute daily and annual TSR surveillances related to excess reactivity. Our path forward for addressing this comment is as follows.</p> <p>We have agreed to use a combination of Startup Instrumentation and Log-N instrumentation to address this issue. The following describes the approach that will be used.</p> <p>Period measurements will be made using the Startup Instrumentation in concert with the Labview based Startup/Channel Program. This measurement will be confirmed by a period measurement using the Log-N Instrumentation.</p> <p>Period measurements using the Log-Ns will proceed as follows:</p> <ol style="list-style-type: none"> <li>1. Establish a stable period in accordance with the applicable SOP.</li> <li>2. Using a calibrated stopwatch and the Log-N meter, measure the doubling time. <ol style="list-style-type: none"> <li>a. Measure the time it takes for the Log-N indicated power to increase by a factor of 2.</li> <li>b. The reactor period is calculated via the following relation:</li> </ol> </li> </ol> $\tau = \frac{T}{\ln 2}$ <p>Where <math>\tau</math> is the reactor period and T is the doubling time. Given the period, reactivity is easily determined from the In-Hour Equation with parameters appropriate for the assembly. The Startup Instrumentation consists of ML-2 (SS-SSC) equipment from the detector to the local counters. The cabling from the experiment building to the control room is general service. The Instrumentation and Lab View based Startup Channel Program are also general service. This lack of pedigree commensurate with the safety significance of the measured parameter (excess reactivity) has come into question.</p>

<b>DNFSB Issue</b> <b>Improper Characterization of Safety-</b> <b>Related Controls</b> <b>(Continued)</b>	<b>Path Forward</b> <b>(Continued)</b>
	<p>The measured parameter is the rate of change of assembly power, which may be measured from the neutron leakage. Thus, this is a difference measurement. One can envision only a finite set of system failures:</p> <ol style="list-style-type: none"> <li>1. The system reads high.</li> <li>2. The system reads low.</li> <li>3. The system reads nothing.</li> <li>4. The system reads intermittently.</li> </ol> <p>The consequences of these failures do not compromise the quality of the measured parameter. Failure 1 results in a difference between two readings that are both biased high. The resultant slope is the same as with no failure. Failure 2 results in a difference between two readings that are both biased low. The resultant slope is the same as with no failure. Failure 3 results in no measurement. Failure 4 results in a nonlinear reading from which a measurement cannot be made.</p> <p>Therefore, excess reactivity measurements may be made with the Startup Instrumentation in support of TSR SRs. These measurements will be confirmed by a measurement on the Log-Ns as described above.</p> <p>The implementation of this alternative period measurement will require the procurement of a calibrated stopwatch, the modification of procedures, and operator training/dry-runs.</p>